SECTION 8
MECHANICAL

8.1 General

This section provides guidance for the preparation and development of the mechanical portion of various design products associated with the engineering and design of civil works features for the Comprehensive Everglades Restoration Plan (CERP). These civil works features include pumping stations, spillways, gated culverts, Aquifer Storage and Recovery (ASR) systems, utility relocations, and administrative facilities. The information in this section is to be used as guidance by all agencies as well as the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (SFWMD) representatives responsible for the engineering and design of these CERP features.

8.2 References

Pump and Ancillary Equipment

EM 1110-2-3102, General Principles of Pumping Station Design and Layout

EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations

ETL 1110-2-313, Hydraulic Design Guidance for Rectangular Sumps of Small Pumping Stations with Vertical Pumps and Ponded Approaches

Hydraulic Institute (HI) 2.1-2.5, Vertical Pumps

Hydraulic Institute (HI) 2.6, Vertical Pump Test

Hydraulic Institute (HI) 9.1-9.5, Pumps – General Guidelines

UFGS 15131A, Vertical Pumps, Axial-Flow and Mixed-Flow Impeller-Type

Reduction Gears

American Gear Manufacturers Association (AGMA) 6010*, (1997: Rev. F) Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives*

American Gear Manufacturers Association (AGMA) 6023, *(1988: Rev. A) Design Manual for Enclosed Metric Module Gear Drives*

UFGS 15005A, Speed Reducers for Storm Water Pumps

Engines

UFGS 15133A, Diesel/Natural Gas Fueled Engine Pump Drives

NFPA 37, Installation and Use of Stationary Combustion Engines and Gas Turbines

Fuel Systems

Florida Administrative Code (FAC) 62-762 for Aboveground Storage Tanks

MIL-HDBK-1022, Petroleum Fuel Facilities

NFPA 30, Flammable and Combustible Liquids

OSHA 1910.106, Flammable and Combustible Liquids

UFGS 13202A, Fuel Storage Systems

UL 142, Steel Aboveground Tanks for Flammable and Combustible Liquids

UL 2085, Insulated Aboveground Tanks for Flammable and Combustible Liquids

Emergency Generator

NFPA 110, Emergency and Standby Power Systems

UFGS 16263A, Diesel Generator Set Stationary 100-2500kW, with Auxiliaries

UFGS 16264A, Diesel Generator Set, Stationary 15-300kW, Standby Operation

Spillways

EM 1110-2-2701, Vertical Lift Gates

EM 1110-2-3200, Wire Rope Selection Criteria for Operating Mechanism

8.3 Project Implementation Report (PIR)

8.3.1 Alternatives Evaluation

8.3.1.1 Pumping Stations

General Requirements

Specific pumping requirements for each pumping station shall be obtained from the hydrology and hydraulic (H&H) engineer. The requirements include the total flow and head requirements for the station, the required number of pumps and their capacity, and the anticipated use for the station (e.g., whether it shall be used for flood control or water supply). Generally, pumps used for flood control shall be driven by diesel engines through right angle reduction gears. Pumps for water supply or seepage pumps may be driven by either electric motors or diesel engines. For the Alternatives Evaluation phase, assume that when electric motor pump drives are used they shall be directly coupled to the pumps with no speed reducer used.

Plates M-1 through M-6 show sections and plan views of typical small-, medium-, and large-sized pumping stations. Plate M-7 shows a complex fuel system for a typical large-sized pumping station.

During the Alternatives Evaluation phase a number of pumping station alternatives may be proposed. The designer must define the project requirements and constraints. Additionally, the general pumping system arrangements, along with an order of magnitude of major equipment sizes and pump bay width requirements will need to be estimated. The pumping equipment information (i.e., pumps, pump drives, and reduction gears) shall be provided to the cost estimator. The equipment sizes and proposed arrangements shall be coordinated with the electrical engineer and provided to the structural engineer so that the required mechanical and electrical spaces can be determined. Any large fuel system requirements (i.e., tanks and tank farms) shall also be provided to the cost estimator and structural engineer.

Pumping stations can be broken into three categories: small-sized, medium-sized, and large-sized. For the purpose of this manual, small-sized pumping stations are assumed to have a total pumping capacity of less than 250 cubic feet per second (CFS), medium-sized pumping stations are assumed to have a total pumping capacity from 250 CFS to 1,000 CFS, and large-sized pumping stations are assumed to have a total pumping capacity of over 1,000 CFS.

Pumping stations shall be sized and arranged in accordance with Hydraulic Institute (HI) standards, EM 1110-2-3102, and EM 1110-2-3105. The intake bays for small and medium-sized pumping stations will follow the guidance of ETL 1110-2-313. The requirements for any formed suction intakes (FSI) shall be evaluated for each pumping station, and based upon the size of the pump(s) and the channel intake design.

Pumping stations will use axial flow or, for systems with large heads, mixed flow pumps. All pumps shall be water lubricated with either product water or treated/filtered canal or well water.

Small-Sized Pumping Stations

The small-sized pumping stations will typically have one to three pumping systems. The pumps shall be axial-flow-type vertical-shaft pumps and will generally be lubricated with product water. For the purpose of the Alternatives Evaluation phase, assume that the power to the pumps shall be provided by diesel engines through right-angle reduction gears (for flood control pumps) or direct-drive electric motors (for water supply pumps). Note that during the Design of Tentatively Selected Plan (TSP) phase, the pump drives and reduction gears will need to be readdressed.

Small-sized pumping stations shall be configured in the same way as the three-bay pump station shown on Plates M-1 and M-2. This layout is similar to a medium-sized pumping station except it does not have an office or toilet room. The engine-driven pumps typically run at less than 500 rpm with an efficiency that ranges from 70-80 percent. The motor-driven pumps typically run at no less than 600 rpm with an efficiency that ranges from 70-80 percent. Diesel engine pump drives shall be in a range of 150 to 250 horsepower each. The electric motor pump drives should generally be limited in size to no more than 200 horsepower each. The electric motor pump drive requirements shall be coordinated with the electrical engineer.

Each of the small-sized pumping stations shall include, but not be limited to, the following various support items:

1. An emergency generator sized to provide power to run pump station auxiliaries.

2. A diesel fuel system, including vaulted, double-wall, aboveground fuel storage tanks capable of holding enough fuel to operate the diesel engine pump drives and/or emergency generator

for 14 continuous days. A floor-mounted, packaged system day tank shall also be provided for each engine pump drive and generator.

3. Hoisting system for maintenance or repair of the pumping equipment.

4. Ventilation system to provide outside air for the operating floor and generator area. The ventilation requirements shall be coordinated with the designer responsible for the louvers.

5. An engine and/or motor controller for each pump drive.

6. A flexible trash rake for cleaning the trash rack.

7. Stilling wells with water level indicators and/or shut-off switches for monitoring and/or operating the pump station.

8. A keel cooler and shaft-driven cooling water pump and expansion tank to cool each main engine.

Medium-Sized Pumping Stations

The medium-sized pumping stations will typically have three to five pumping systems. These pumps may have a suction bell or FSI, and based upon discharge water elevation requirements, may be conventional discharge or siphon-discharge type. At times, a small, electric motor driven pump is included for seepage control and its flow rate is not included in the total flow capacity of the station. The pumps in these stations shall be axial-flow-type vertical-shaft pumps and will generally be lubricated with product water. Power to the pumps shall be provided by either diesel engines through right angle reduction gear drives or by direct-drive electric motors. Right-angle gears shall be equipped with a backstop clutch.

Medium-sized pumping stations shall be configured similarly to that shown on Plates M-3 and M-4. Pumps with a siphon discharge arrangement shall be configured similar to the arrangement shown on Plate M-6. The engine-driven pumps typically run at less than 500 rpm with an efficiency that ranges from 70-80 percent. Motor-driven pumps typically run at no less than 600 rpm with an efficiency that ranges from 70-80 percent. The diesel engine pump drives shall be in a range of from about 300 to 1,000 horsepower each. The electric motor pump drives shall generally be limited in size to no more than 300 horsepower each. The electric motor pump drive requirements shall be coordinated with the electrical engineer.

Each of the medium-sized pumping stations will include, but not be limited to, the following various support items:

1. An emergency generator sized to provide power to run pump station auxiliaries.

2. A diesel fuel system, including vaulted, double-wall, aboveground fuel storage tanks capable of holding enough fuel to operate all engine driven pumps and the emergency generator for seven continuous days. A floor-mounted, packaged system day tank shall also be provided for each engine pump drive and generator.

3. Manual or electric bridge crane hoisting system for maintenance or repair of the pumping equipment.

4. Toilet facility with a water closet and lavatory.

5. Potable water system and a septic system for the plumbing fixtures.

6. Ventilation system to provide outside air for the operating floor, generator area, and toilet room. The ventilation requirements shall be coordinated with the designer responsible for the louvers.

7. A Programmable Logic Controller (PLC)-based engine and/or motor control system for each pump drive.

8. A flexible trash rake for cleaning the trash rack.

9. Stilling wells with water level indicators and/or shut-off switches for monitoring and/or operating the pump station.

10. Cooling of each main engine shall be by way of a keel cooler and shaft-driven cooling water pump and expansion tank, or by a motor-driven raw water pump supplying raw water to the engine expansion tank.

Large-Sized Pumping Stations

The large-sized pumping stations will typically have three to five pumping systems, and shall be configured similarly to that shown on Plates M-5, M-6, and M-7. When analyzing alternatives that include large-sized pumping stations, the long lead-time needed for the delivery of the pumping equipment needs to be addressed early. A long delivery time for the large pumps, engines, and gears may require two separate contracts, one for machinery and another for building construction, which add significant time to the project schedule

Features commonly found in large-sized pumping stations are listed below. Most of these features are also found in the medium and small-sized pumping stations.

The large-sized pumping stations will have the following features:

1. Pumps: A large-sized pumping station may have several large pumps over 75” in diameter. These large pumps may be designed with FSIs, and may include rectangular pipe for the intake and discharge. FSIs have been shown to be more efficient than suction bell intakes.

   Large-sized pumping stations may also incorporate smaller electric motor-driven or diesel engine-driven pumps. These shall be similar to those described previously for small and medium-sized pumping stations.

   In order to reduce the engine size needed to overcome the start-up head for large pumps, siphoning systems are used to fill the entire chamber of the pump above its summit. For normal operations, priming is accomplished by means of the station vacuum system; however, with the impeller submerged and depending on the characteristics of the equipment offered, the pumps may be self-priming (in an emergency). Each pump shall be equipped with an automatic water lubrication system for its bearings.

2. Power Required to Drive Pumps: The main engines shall be standard model full-diesel types, 2 or 4-cycle, with heat exchanger cooling. Diesel engine horsepower will generally range from about 750 to 2,500 hp. The fuel system for each main engine will consist of a floor mounted, packaged system day tank sized to hold from four to eight hours of fuel (typically up to 660 gal capacity) to supply the diesel engine (note that NFPA 37 limits the total amount of day tank fuel storage within a facility). Cooling of each main engine shall be by means of a closed system consisting of a heat exchanger, expansion tank, and engine-driven jacket water-circulating pump. Water for cooling the heat exchanger shall be provided by the raw water system described below. Engines of the sizes used for large pumping stations typically will use compressed air for starting. Starting air system for the main engines and for the engine generator sets will consist of a combination engine-motor-driven compressor with air receiver tanks located on the auxiliary equipment platform at the intake side of the station. A PLC-based engine instrument panel shall be provided to each engine for monitoring and controlling the engines. The engine instrument panel shall be coordinated with the electrical engineer.

3. Speed Reducers: Power shall be transmitted from the engines to the pumps by means of right-angle type gear reducer units with built-in backstop clutches to prevent reverse rotation.

4. Backflow Gates: Siphon-discharge-type pumps have their discharge pipe below water. Backflow control shall be provided at the discharge outlet to prevent water from backing up into the pump. Each pump discharge tube shall be equipped with twin vertical-lift type gates with relief flaps located at the siphon discharge terminus as shown on Plate M-6. Primary functions of the gates are to protect against backflow during pump shut-down and non-pumping periods when the discharge pool is above the invert, and to prevent the possibility of reverse siphoning due to incomplete breaking of the prime during pump shut-down. Each gate shall be raised and lowered by a screw-stem with a Limitorque-type electric motor operator controlled from within the station.

   A means to allow application of compressed air to the invert of the discharge of the pump shall be provided as a secondary (emergency) means of preventing backflow.

5. Raw Water System: The raw water for the main engine heat-exchanger and engine-generator sets, as well as for station service and domestic use, shall be provided by a system of deep-well turbine type pumps installed in a common raw water intake structure.

6. Vacuum System: A vacuum system shall be provided to ensure adequate priming of the main pumps. If required, the system may also be used to produce a low-pressure air lock within the main pump discharge tubes to assist in preventing backflow during periods of high discharge stages.

7. Fuel Oil Storage System: Aboveground storage tanks (ASTs) shall be located at a safe distance from the station. ASTs shall be concrete-vaulted and have a dual containment feature. Fuel capacity may be as much as 50,000 gallons and contained in multiple tanks. Fuel capacity shall be for seven days, 24-hours/day with all engines and generators continuously operating at the maximum fuel consumption rate.

8. Station Crane/Hoist: For a large pumping station, a double-girder, and overhead bridge-type electric crane will typically be used. The crane/hoist shall be capable of handling the maximum load anticipated to be lifted in the station, up to 30-ton loads. The crane/hoist will

handle pumping station equipment such as engines, reduction gears, or pump components during initial installation, as well as for general service thereafter.

9. Diesel Engine-Generator Sets: Large pumping stations may use several diesel engine-driven generator sets (gen-sets) up to 500 kW each. These generators must provide sufficient power to operate the station at full capacity, including running all auxiliary equipment, for as long as seven continuous days.

10. Trash Rake: Trash rake systems may be one of two types; 1) an automatic, continuously rolling, flex rake and trash rack system, or 2) an electrically, hydraulically, and/or pneumatically powered rail-mounted traveling trash rake and hoist car assembly. In the latter case, raking operations and car travel shall be either automatic or push-button-controlled by an operator.

8.3.1.2 Wastewater Treatment Systems

The design of wastewater treatment systems greatly depends on the required discharge water quality and flow rate of the discharge. These variables depend upon the receiving point and/or area of discharge, soil type, flora and fauna, ecology, and topography. The mechanical and environmental engineers need to determine the desired discharge water quality and flow rate to prepare a design of the wastewater treatment system. From a design standpoint, the desired discharge water quality and the flow rate would depend on the source of the influent wastewater, influent wastewater pollutants/contaminants, influent flow rate, applicable treatment technology, and levels of treatment such as primary, secondary and/or tertiary.

Other factors to be considered in the design of the wastewater treatment systems are the topography of the terrain, which would determine gravity flow, use of pumps, or combination of both; piping systems, which would include pipe lengths and sizes, valves, manholes, siphons; and auxiliary units such as electrical power sources and diesel engines, fuel tanks, and generators. For a successful design of a wastewater treatment system, it is necessary to coordinate with all engineering disciplines involved in the project.

The mechanical engineer shall provide a description and the approximate capacity of each of the major pump systems to the cost estimator.

The treatment portion of the wastewater shall be described by an environmental engineer or related discipline.

8.3.1.3 Spillways

The following items shall be addressed:

1. The number of gates, their size, the gateway opening dimensions, and the head and tailwater elevations shall be obtained from the H&H engineer. Coordinate this information with the structural engineer, who shall provide the weights of the gates. The operating mechanism for each gate shall be the electric motor-driven/double stage reduction gear type, hydraulic cylinder with wire rope type, or a hinged gate with inflatable bladder type.

   The electric, motor-driven double stage reduction gear, if used, shall be centered on the operating platform above each gate and shall be of the double-input, double-output shaft type as shown on Plate M-8. In addition, a cable slack limit switch, a rotary limit switch, and gate travel readout or gate position indicator system shall be provided.

The hydraulic cylinder with wire rope type of operating mechanism, if used, is made up of a hydraulic cylinder that is connected, via its piston rod, to the spillway gate with wire ropes routed through an arrangement of sheaves. The system allows a short stroke to raise the gate a longer distance. A centralized hydraulic power unit shall be used for multiple gates and hoisting units.

The operating platform for the double stage reduction gear and hydraulic cylinder with wire rope types of systems shall be designed to support the weight of the gate, the operating mechanism, and any thrust loads developed by the system. The operating platform shall also be large enough to accommodate the layout of the complete hoist system, including sufficient room for maintenance. The design shall be coordinated with the structural engineer.

The bottom-hinged spillway gate utilizes a row of steel gate panels supported on their downstream side by inflatable air bladders. The downstream elevation maintained by the gates can be variably adjusted within the system control range (full inflation to full deflation) by controlling the pressure in the bladders. As the pressure is increased or lowered, the gate rises or lowers and accurately maintains the downstream water elevation at user-selected set points. This type of gated spillway requires a compressed air system, with the compressor located in a control house. Air supply lines shall run to the gate bladders from the control house.

2. Each spillway shall have a Liquefied Petroleum Gas (LPG) fueled generator for backup power. The generator shall be located in a control room. A LPG fuel system shall also be provided.

3. Stilling wells with water level monitoring equipment upstream and downstream of the spillway shall be provided.

4. The cost estimator shall be provided the number of gate operators and the approximate size of the generator and LPG fuel tank.

8.3.1.4 Gated Culverts

This section covers not only structures listed specifically as gated culverts, it also covers control, drawdown, and equalizer structures, which essentially operate as gated culverts. Flow through each structure will depend on the area of opening per barrel, the number of barrels in the culvert, and the height of water impounded behind the gate.

The following items shall be addressed:

1. The gated culvert(s) shall have a commercially available self-contained aluminum or steel gate unit. A rising stem, suitable for attaching to a concrete bulkhead or corrugated metal pipe, shall be used to raise and lower the gate via an electric actuator/operator. The electric operator shall include, but is not limited to, the motor, actuator unit gearing, limit switch gearing, position limit switches, torque switches, stem nut, declutch lever, and handwheel as a self-contained unit.

2. The cost estimator shall be provided the number of gate operators.

8.3.1.5 Aquifer Storage and Recovery (ASR) Well Facilities

1. Pumps/Wellhead: The water supply rate and estimated aquifer head range needs to be defined by the geotechnical engineer for each alternative site location. Depending on conditions, a vertical turbine, submersible, or horizontal pump may be suited for the well. Pump selection will determine piping and valves needed for each wellhead configuration.

2. Raw Water Treatment Facilities: Water stored or injected by the ASR well is required to be treated to meet all primary and secondary drinking water standards. Source water quality shall be evaluated at each intended location so that the relative difficulty and cost of filtration and treatment is included for each alternative.

3. Utility and Site Issues: The relative difficulty of providing commercial electric power to the ASR well alternative site locations shall be determined. Electricity shall be needed to power the ASR pump motors, as well as the treatment equipment and telemetry-related sensors and controls. Remoteness will increase periodic maintenance costs including filter cleaning and the delivery of disinfectant chemicals.

4. The cost estimator shall be provided the number of ASR pump systems required and a brief description of the pump and engine/motor pump drive requirements.

8.3.1.6 Utility Relocations

If gas, sewer, or other non-electrical utilities have to be relocated, the extent of these shall be addressed in the narrative. The points of contact for the various utilities shall be provided. All utility relocation work shall be coordinated with the electrical engineer.

8.3.1.7 Required Documentation/Products

The following shall be provided for all structures or items being considered during the Alternatives Evaluation phase:

1. Narrative

    a. References used in the analysis, including government design documents, industry standards, and information gathered from the end user shall be listed.

    b. Proposed type of pumping systems, spillway hoist, utility relocations, and associated fuel system requirements shall be explained.

    c. Any environmental concerns and actions taken to address them shall be listed.

2. Drawings

    a. A minimal, basic floor plan indicating, as applicable, bay widths, space for major items of mechanical and electrical equipment, and hoisting equipment to provide a general arrangement of what is being analyzed shall be provided.

b. For pump stations, section(s) indicating pump arrangement, elevation and discharge type shall be provided.

c. A plan indicating any substantial fuel system items shall be provided.

8.3.2 Design of Tentatively Selected Plan

The mechanical engineer shall perform sufficient Design of TSP to provide input to the cost estimator and the design shall be at such a point that allows the engineer to proceed directly to the production of plans and specifications.

8.3.2.1 Pumping Stations

The selected pumping station(s) shall be sized and arranged in accordance with HI standards, EM 1110-2-3102, EM 1110-2-3105, and other applicable publications. The intake bays for pumps with suction bells will also follow the guidance of ETL 1110-2-313. The requirements for any formed suction intakes at pumps shall be evaluated as needed for each pumping station, and shall be based upon the size of the pump(s) and the channel intake design.

The pumping station features shall be as indicated in the Alternatives Evaluation section.

Coordination

The final pumping requirements for the pumping stations shall be analyzed in conjunction with the H&H engineer to determine the final pump mix (i.e., the number of pumps, the size of each of the pumps, and which pumps are for flood control and which are for water supply). The mechanical engineer shall use judgment and cost benefit life cycle analysis and coordinate with the H&H engineer to determine the appropriate pump mix that addresses, for example, whether several small pumps may be more advantageous (in terms of cost and/or ease of construction) for the pumping station than two large ones. Once finalized, the pump sizes can be determined and the width of the pump bays can be sized.

The engineer must also coordinate with the end user and further define the end user's requirements and requests. The engineer shall then incorporate the applicable items into the design.

Design Requirements

The pumping system arrangements shall be finalized at this point. Pumping system items to be determined include those described in the Alternatives Evaluation phase and the following:

1. Whether the pumps will have suction bell intakes or Formed Suction Intakes (FSI).

2. Dimensions of the FSI, if applicable.

3. The type of pump discharge system (i.e., a standard horizontal discharge above the high water elevation or a siphon discharge). Note that a siphon discharge will likely require backflow gates that can be raised during pumping.

4. Electric motor and/or diesel engine and reduction gear space requirements, along with requirements for spacing day tanks and the emergency generator(s). Use a minimum of three manufacturers for sizing purposes so that the space allocated for equipment is adequate.

5. Final pump bay widths.

6. The required minimum height of the crane hook based upon the sizes of the pumping equipment being removed. This height shall be coordinated with the structural and electrical engineers to set the height of the pumping station.

7. Whether the station will incorporate roof hatches for maintenance purposes. Coordinate this with the end user and the structural engineer.

8. Determine the type of overhead crane to be used and its capacity.

9. Determine the sizes of any required major components for the accessories to the pumping equipment. This includes the compressed air systems, the vacuum systems, the engine cooling systems, and the external pump lubrication systems.

10. Determine the type of trash rake system to be used.

11. Finalize the size of the required fuel tanks along with the general layout for the fuel system.

12. Size the ventilation system for the pumping station to determine intake and exhaust air requirements. Coordinate the ventilation requirements with the designer responsible for the louvers.

13. Determine the size of the domestic water and sewer systems (fixture units), and the water heater.

14. Coordinate with the electrical engineer regarding the engine and/or motor control system for each pump drive.

15. Locate stilling wells with water level indicators and/or shut-off switches for monitoring and/or operating the pump station. A stilling well with a low-water cut-off switch shall be located in each pump bay to ensure that they do not operate below a safe level for the pump. Stilling wells for water level indication shall be provided upstream and downstream of the pumping station, as well as in each pump bay.

Design Considerations

1. The ventilation system shall be designed in a manner to optimize the airflow across the engines/motors. It shall avoid intake or exhaust openings over electrical equipment. Intake or exhaust openings shall not be installed on the roof.

2. Engine pump drives are to be rated for continuous duty. That is, the engines shall be capable of driving the pumps at rated speed and at full load for 24 hours a day, seven days a week, continuously (except for routine maintenance), for several months at a time. No ratings that are specific to particular manufacturers (e.g., WMR ratings) shall be acceptable.

3. Separate day tanks for each engine and generator shall be used. A siphon priming system for top-suction fuel storage tanks shall be provided.

4. The overhead crane travel shall be coordinated with the equipment to be lifted, loaded, and unloaded. The building design shall include room for a vehicle to enter the facility for loading and unloading pumping equipment. This shall be coordinated with the electrical and structural engineers.

5. Electrical requirements shall be coordinated with the electrical engineer for primary and emergency power (generator).

6. In accordance with paragraph 7-4a of EM 1110-2-3102, the basic requirement for pump discharge lines in which backflow can occur without siphon action is to provide two means of preventing backflow, one means for normal use and the other for emergency use in the event of failure of the normal method. In siphon discharge systems, flap gates shall not be considered a positive means of backflow prevention.

8.3.2.2 Wastewater Treatment Systems

The selected wastewater treatment system shall be finalized at this time. A conceptual layout of the system, to include treatment facilities, pump stations, piping, valves, manholes, motors, engines, and fuel tanks shall be finalized and coordinated.

Coordination

Prior to finalizing the wastewater treatment systems, the system shall be coordinated with all engineering disciplines for review and approval. The mechanical engineer shall determine the proper selection and arrangements of units and systems applicable to the system, such as pumps, pipes, valves, manholes, engines, fuel tanks, and auxiliary mechanical systems. The environmental engineer shall design the treatment facilities. The engineering disciplines must then integrate their various designs to provide a unified design capable of providing the final output requirements of the system. The design shall be in compliance with all applicable local, state, and federal agencies.

Design Requirements

1. Whether the system will obtain influent from a wastewater treatment plant, from the surface water, groundwater, or a combination thereof shall be determined.

2. Whether pumps shall be required, and/or if the system shall be gravity fed shall be determined.

3. Piping requirements, both internal and external of the treatment facilities, shall be determined. Pipe types, sizes, and arrangements shall be provided.

4. Whether the treatment facility shall be constructed, prefabricated, or a combination of both shall be determined.

5. Use of electric motors, diesel engines, and auxiliary units such as generators or combination depending upon sizes of pumps used shall be determined.

6. Use of valves and manholes shall be determined.

Design Considerations

1. The wastewater treatment system shall be designed to optimize gravity flow. This will result in the use of smaller pumps utilizing less power from electricity or diesel fuel, resulting in a reduction in operational, fuel, and equipment costs.

2. Coordination with the structural engineer to design appropriate housing for equipment protection from vandalism and the elements shall occur.

8.3.2.3 Spillways

Operating Mechanisms

Finalize the number of gates, their size, the gateway opening dimensions, and the head- and tailwater elevations with the hydraulic engineer. Coordinate this information with the structural engineer, who shall provide the weights of the gates. Select the operating mechanism for each gate from either the electric motor-driven/double stage reduction gear type, hydraulic cylinder with wire rope type, or a hinged gate with inflatable bladder type.

The double stage reduction gear, if used, shall be centered on the operating platform above each gate and shall be of the double-input, double-output shaft type. A double reduction gear consisting of two separate gearboxes joined together is not acceptable. In addition, a slack cable limit switch, a rotary limit switch, and gate travel readout or gate position indicator system shall be provided. The rotative limit switch shall be provided to delimit the upper and lower position of the gate. The complete hoist assembly, including hoist frame, drum, shaft(s), reduction gear, motor, bearings, supports, cables, sheaves, covers, and all hardware shall be designed to handle all loads encountered, and shall be configured to eliminate any interferences of moving parts or systems.

The hydraulic cylinder with wire rope type of operating mechanism, if used, is made up of a hydraulic cylinder that is connected, via its piston rod, to the spillway gate with wire ropes routed through an arrangement of sheaves. Select the type of wire rope and sheave arrangement that shall be used to lift the gates. Also, size and locate the centralized hydraulic power unit. Coordinate this with the structural engineer.

The operating platform shall be designed in coordination with the structural engineer to support the weight of the gate, the operating mechanism and any thrust loads developed by the system. The operating platform shall also be large enough to accommodate the layout of the complete hoist system, including sufficient room for maintenance and adequate clearance between the operating mechanism and the fence.

The gate lift system design shall include the following features:

1. All mechanical components shall be installed on a common frame to facilitate the removal of the operating mechanism from the platform as a unit, allowing minimum disturbance of alignments between components.

2. The systems shall be capable of lifting the gate at a speed of six inches per minute ± 0.6 inches per minute.

3. The electric motor and brake, if used, shall be interlocked for a fail-safe operation.

4. A removable wire rope shall link between the gate and each wire rope connection at the gate.

5. After opening the gate to the maximum allowed by the system, a set of dogging slings shall be provided to support the gate at an intermediate open position.

6. The LPG-driven generator shall be sized for backup power. The capacity of the generator shall be coordinated with the electrical engineer. The capacity of the LPG fuel system shall also be provided.

7. The location of the stilling wells shall be indicated with water level monitoring equipment upstream and downstream of the spillway.

8.3.2.4 Gated Culverts

Size the electric operator in coordination with the structural and electrical engineers. The electric operator shall include, but is not limited to, the motor, actuator unit gearing, limit switch gearing, position limit switches, torque switches, stem nut, declutch lever, and hand wheel as a self-contained unit. The actuator shall have sufficient capacity to raise or lower the gate at a speed of six inches per minute against the operating heads. The hand wheel shall operate in the clockwise direction to close. The external declutch lever shall be padlockable in either the manual (hand wheel) or motor mode. Indicate the location of the stilling wells with water level monitoring equipment upstream and downstream of the gated culvert.

8.3.2.5 Aquifer Storage and Recovery (ASR) Well Facilities

Pumps/Wellheads: Choose whether to use a vertical turbine, submersible, or horizontal pump. Pump/drive selection needs to operate under a wide range of head conditions. If a vertical turbine pump is chosen, it may be used both for water injection and recovery by changing the flow with piping and valves, while submersible pumps require separate pumps for each flow direction. Piping and valves are arranged to suit the pump selection. Develop a site plan, including mechanical and electrical equipment layout, control building size requirements, and intake/discharge connections with source and treatment facilities.

Raw Water Treatment Facilities: Evaluate source water quality with regard to all applicable contaminants, so that the cost estimate includes all necessary filtration and treatment equipment. Choose the most cost-effective, suitable method that uses disinfectant in conjunction with in-bank horizontal wells, slow sand filters, direct filtration, or conventional coagulation. Develop the design for the method chosen for providing dissolved oxygen to the returned surface water, so that its cost can be included in the project estimate. Overall costs are a combination of the infrastructure, chemicals, energy and manpower needed to set up and operate the treatment facilities. Consider all of these components in order to select the most cost-effective equipment package.

Utility and Site Issues: Coordinate with the electrical engineer to help determine the cost of providing commercial electric power to the selected ASR well location. Decide whether to recommend telephone service, which is normally provided if the facility is to be occupied.

Coordinate location of new poles and lines with utility companies. Determine the telemetry-related sensor, relay and control equipment instrumentation required. Ensure that the site accessibility and maintenance difficulties are included as a factor in pump, wellhead, and water treatment equipment selection.

8.3.2.6 Utility Relocations

Contact the non-electrical utility owner(s) to determine the best procedure in which to have the utilities relocated. If the utility owner is responsible for relocating the utilities, determine what cost shall be required to compensate the utility owner for the work. Coordinate any utility work with the electrical engineer.

8.3.2.7 Required Documentation/Products

The following documentation and products shall be provided:

1. Technical Write-Up - A technical write-up shall be developed, which shall include, but not be limited to, the following items as applicable:

    a. List all references used in the analysis including government design documents, industry standards, and information gathered from the end user.

    b. Provide pump total head, engine sizing, fuel system, ventilation, water and sewer system, and any other calculations needed to demonstrate that the mechanical systems have been properly sized.

    c. Describe the type of pumping systems and fuel system requirements. List all assumptions made.

    d. Provide representative pump curves, equipment catalog cuts, and other manufacturer's information to support the sizes of the equipment indicated on the drawings. Also, indicate the weights of major pieces of equipment that are to be lifted by the overhead crane.

    e. Provide hoisting load calculations.

2. Drawings

    a. Pumping Stations

        - Provide a floor plan indicating bay widths and showing the locations for major items of mechanical and electrical equipment.
        - Provide section(s) indicating pump intake and discharge arrangements, elevations, and dimensions of the FSI (if applicable).
        - Coordinate with the structural and electrical engineers on the size and location of the exhaust fans and intake louvers. These sizes and locations are typically indicated on the structural elevations and sections.
        - Provide a site plan indicating any substantial fuel system items and the number and size of fuel tanks. Also, provide for a fuel delivery area that includes room for delivery trucks to drive through and turn around for departure. Provide sufficient room for inspection of the fuel system.

- Locate the water level indicators and the low-water pump shutdown switches in the intake pump bays and indicate the locations on the floor plan and section(s).
- Locate, on a site plan, the water level indicating stilling wells in the intake and discharge channels.
- Indicate on a site plan the source of the domestic water and sewer utilities, and/or where the water well and/or septic system and drain field shall be located.

b. Spillways

- Provide a plan view indicating the general hoist type and showing the locations for major items of mechanical equipment.
- Provide a section indicating the general hoist type.
- Provide a plan view of the control house indicating the approximate size of the gen-set and showing that it will fit. Also, show the location of the fuel tank and provide for a fuel delivery area that includes room for delivery trucks to drive through and turn around for departure.
- Locate, on a site plan, the water level indicating stilling wells in the intake and discharge channels.

c. Gated Culverts

- Indicate any required trash rake that may be required on a trash rack for any gated culverts.

8.4 Plans & Specifications

The Plans & Specifications (P&S) phase includes the final design documents. These include the preparation of contract plans and specifications, along with the preparation of a Design Documentation Report (DDR) and a design analysis. The preparation of the P&S may be broken into multiple phases (e.g., 30%, 60%, and final submittals). For 60% submittals, specifications shall be provided that shall describe the systems up to the actual specifying of the products.

8.4.1 Pumping Stations

The pumping station(s) shall be sized and arranged in accordance with HI standards, EM 1110-2-3102, EM 1110-2-3105, and other applicable publications as indicated following.

Design Requirements

The pumping station design shall be finalized at this point. This includes refinement and completion of the information that was prepared in the PIR phase. The work shall include, but is not limited to, the following:

1. The complete design of the fuel, compressed air, vacuum, exhaust, and lubricating oil systems.

2. The design of the station’s plumbing system (potable water and sanitary sewer). The design of the HVAC system that will support office spaces.

3. The design of the trash rake.

4. The design of the stilling well system.

5. The design of the overhead crane.

Design Considerations

1. Design the ventilation system in a manner to optimize the airflow across the engines/motors. Avoid intake or exhaust openings over electrical equipment. Do not install intake or exhaust openings on the roof.

2. Engine pump drives are to be rated for continuous duty. That is, the engines shall be capable of driving the pumps at rated speed and at full load for 24 hours a day, seven days a week, continuously (except for routine maintenance), for several months at a time. No ratings that are specific to particular manufacturers (e.g., WMR ratings) shall be acceptable.
3. Use separate day tanks for each engine and generator.

4. Coordinate the overhead crane travel with the equipment to be lifted so that the walls or other equipment will not keep large items (such as pumps) from being lifted.

5. In accordance with Paragraph 7-4.a. of EM 1110-2-3102, the basic requirement for pump discharge lines in which backflow can occur without siphon action is to provide two means of preventing backflow: one means for normal use and the other for emergency use in the event of failure of the normal method. In siphon discharge systems, flap gates shall not be considered a positive means of backflow prevention.

6. The designer shall check the HVAC design calculations and ensure that all loads, including the heat coming through the wall from the pump bays, are considered. A sufficiently large air-conditioning unit shall be provided that is not excessively over-sized. Consider using a split system room unit, thereby minimizing the size of the penetration through the wall of the office. Note that over-sizing the air-conditioning unit can lead to moisture problems.

7. For flood control pumping stations, provide a water heater for hot water service to the shower, lavatory, and sink.

8. Require that engine sizing and reduction gear selection be the responsibility of the pump supplier.

9. Assume "severe" operating conditions when assigning an application factor to reduction gears. According to Unified Facilities Guide specification 15005A, the reducer application factors are stated as follows: "where reducer operating conditions are considered severe, the application factors of 1.75 (electric motor) and 2.0 (diesel engine) may be used to increase reliability."

10. Provide a mechanical means to hold up the flap gates when the pumps shall be operated for long periods of time.

11. Provide grease lines for lubricating the flap valves up to the service walkway on the discharge side of the pumping station.

12. The clear opening between bars in a trash rack should not exceed three inches. Bar spacing shall be coordinated with the pump manufacturer via information in the contract specifications for the pump.

13. Coordinate the cooling of the generators – either air or water-cooling – with the cooling of the other major items in the station.

14. All major mechanical items of pumping equipment shall be provided with a minimum two-year warranty.

8.4.2 Administrative Facilities

Provide the complete design for the mechanical systems for administrative facilities including all HVAC, plumbing, and, if required, fire protection.

8.4.3 Wastewater Treatment Systems

All mechanical units and systems applicable to the final design of the wastewater treatment system shall conform and/or be designed according to applicable standards. The integration of the units and systems to provide the complete design of the wastewater system shall also conform to all applicable standards.

Design Requirements

The wastewater treatment system design shall be finalized at this point. This includes refinement and completion of the information that was prepared in the PIR phase. The work shall include, but not be limited to, the following:

1. Design of system to provide influent from a wastewater treatment plant, from surface water, groundwater, or a combination thereof.

2. Design of pumps and pump stations, if necessary.

3. Design of piping requirements both internal and external of the treatment facilities and that include pipe types, arrangements, and sizes.

4. Design to include electric motors, diesel engines, and auxiliary units such as generators or a combination depending upon sizes of pumps used.

5. Design of valves and manholes.

6. Design connections of mechanical requirements to the wastewater treatment facilities.

Design Considerations

1. Design the wastewater treatment system to optimize gravity flow. This will result in the use of smaller pumps utilizing less power from electricity or diesel fuel and resulting in a reduction in operational, fuel, and equipment costs.

2. Coordinate with the structural engineer to design appropriate housing for equipment protection from vandalism and the elements.

8.4.4 Spillways

The spillway gate hoist design shall be finalized at this point. This includes refinement and completion of the information that was prepared in the PIR phase. The work shall include, but is not limited to, the following:

1. The complete design of the LPG fuel system for the generator set.

2. The complete design of the ventilation system for the control house.

3. The complete design of the gate hoist system, including the hoist frame if applicable.

4. Finalize the location of the stilling wells upstream and downstream of the spillway with the hydraulics and hydrology engineer and the civil-site engineer. These stilling wells shall come complete with water level monitoring equipment in accordance with SFWMD standards.

8.4.5 Gated Culverts

The following items need to be addressed:

1. Complete the design for the hoist for the culvert gate. The gate, having the frame attached to a bulkhead over the culvert pipe or having a spigot or flanged connection to the culvert pipe, shall be lifted by an electric actuator/operator through the gate's stem.

2. Finalize the location of the stilling wells upstream and downstream of the gated culvert with the hydraulics and hydrology engineer and the civil-site engineer. These stilling wells shall come complete with water level monitoring equipment in accordance with SFWMD standards.

8.4.6 Aquifer Storage and Recovery (ASR) Well Facilities

Specify pump/drive wellhead system criteria after coordinating complete pump/drive system selection with the pump manufacturer. Water treatment facility equipment functions and capabilities need to be detailed. The manufacturer of the equipment needs to be coordinated. Verify that water treatment facility flow and function are compatible with the selected pump and wellhead. Pertinent technical standards for the equipment shall be researched and listed.

Design Requirements and Considerations

1. Vertical turbine pump system is preferred, since bypass valves and piping allow use of a single pump for both well intake and discharge.

2. Solenoid valves, with manual override, shall be specified to allow the option of telemetry control.

3. Develop a detailed site plan for the complete water intake and discharge system.

4. Finalize the number of stages of the selected pump. Select a system that allows stages to be added or removed in the field to meet possible changing future head conditions.

5. To avoid stagnation problems when the pump is not operating, it may be necessary to maintain a trickle flow of chlorinated water. Include the necessary piping, valves, equipment, and operation schedule to provide this flow in the design.

6. Select open line shaft construction for the pump bowl assembly, so that water instead of oil is used to lubricate both the pump and the column bearings.

7. Proper pump column size selection is important to minimize friction head loss.

8. Coordinate flow between the pump and water treatment facility, so that automatic shutdown of both occurs if either one malfunctions.

8.4.7 Utility Relocations

Provide a complete design of the gas, water, sewer, or other non-electrical utility relocations. If the utility owner is performing the relocations at the construction contractor's expense, provide a point of contact with the utility and the cost that the utility owner indicates that it will charge. Coordinate any utility relocation work with the electrical engineer.

8.4.8 Required Documentation / Products

1. Drawing Requirements

    a. Provide a fully coordinated final plan indicating all of the mechanical equipment.

    b. Provide a fully coordinated final section(s) indicating all of the mechanical equipment.

    c. Provide a site plan for the complete fuel system. Provide a larger scale site plan if any mechanical utilities are relocated.

    d. Provide all necessary details, sections, and schematics to clearly define what is to be constructed.

2. Narrative - The narrative shall include, but is not limited to, the following applicable items:

    a. List all references used in the analysis including government design documents, industry standards, and any information gathered from the end user.

    b. Provide final calculations for all mechanical systems.

c. Provide equipment catalog cuts and other manufacturer's information to show representative equipment that can meet the requirements of the plans and specifications. Use a minimum of three manufacturers to help establish that the specified equipment is not proprietary.

3. Specifications

   Finalize all specifications necessary to complete the mechanical portion of the construction documents.

4. Guidance for the Cost Estimate

   The cost estimate shall be based on the contract plans and specifications. As an aid to the cost estimator, provide any manufacturer's supplied costs for major items of mechanical equipment.